

What is claimed is:

1. A sensing system adapted to locate a desired position for a manufacturing operation on a workpiece, comprising:

5 a first portion including a magnet having a magnetic field emanating therefrom and at least one field-directing member adapted to provide a shaped magnetic field portion of the magnetic field, the shaped magnetic field portion at least partially extending through the workpiece and outwardly beyond a second surface of the workpiece; and

10 a second portion including a magnetic field sensor moveable through at least a portion of the shaped magnetic field portion extending outwardly beyond the second surface, the magnetic field sensor being adapted to sense a characteristic of the shaped magnetic field portion indicative of the desired position for the manufacturing operation.

2. The sensing system of Claim 1, wherein the magnet includes a permanent magnet.

15 3. The sensing system of Claim 1, wherein the magnet includes an electromagnet.

4. The sensing system of Claim 3, wherein the first portion further includes a source coupled to the electromagnet.

20 5. The sensing system of Claim 1, wherein the at least one field-directing member includes a conically-shaped field-directing portion.

6. The sensing system of Claim 1, wherein the at least one field-directing member includes an axisymmetrically-shaped field-directing portion.

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7. The sensing system of Claim 1, wherein the at least one field-directing member includes a frustum-shaped field-directing portion.



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8. The sensing system of Claim 1, wherein the at least one field-directing member includes an outer portion having a first magnetic permeability and an inner portion having a second magnetic permeability.

5 9. The sensing system of Claim 8, wherein the inner portion includes a hollow cavity.

10. The sensing system of Claim 8, wherein the outer portion includes a first material and the inner portion includes a second material.

10 11. The sensing system of Claim 1, wherein the shaped magnetic field portion includes an approximately spherical portion.

12. The sensing system of Claim 1, wherein the shaped magnetic field portion includes an approximately axisymmetrical portion.

15 13. The sensing system of Claim 1, wherein the magnetic field sensor includes a linear Hall effect sensor.

20 14. The sensing system of Claim 1, wherein the magnetic field sensor is further adapted to transmit one or more signals based on the sensed characteristics of the shaped magnetic field portion.

25 15. The sensing system of Claim 14, wherein the second portion includes a data analyzer, the magnetic field sensor being adapted to transmit the one or more signals to the data analyzer.

16. The sensing system of Claim 1, wherein the magnetic field sensor is further adapted to determine the desired location based on the sensed characteristics of the shaped magnetic field portion.

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17. The sensing system of Claim 1, wherein at least one of the first and second portions includes a position control assembly operatively coupled to a respective one of the field-directing member and the magnetic field sensor.

5 18. The sensing system of Claim 1, wherein at least one of the first and second portions includes a position control assembly operatively coupleable to the workpiece and adapted to controllably position a respective one of the field-directing member and the magnetic field sensor.

10 19. The sensing system of Claim 18, wherein the position control assembly includes:
a track assembly adapted to be operatively coupleable to the workpiece; and
a carriage assembly operatively coupled to the track assembly and to the respective one of the field-directing member and the magnetic field sensor.

15 20. The sensing system of Claim 19, further comprising a controller operatively coupled to the carriage assembly and adapted to transmit one or more control signals to the carriage assembly to controllably position the respective one of the field-directing member and the magnetic field sensor.

20 21. A manufacturing assembly, comprising:
a manufacturing tool adapted to perform a manufacturing operation on a workpiece; and
a sensing system adapted to be operatively engaged with the workpiece, wherein the sensing system includes:

25 a first portion including a magnet having a magnetic field emanating therefrom and at least one field-directing member adapted to provide a shaped magnetic field portion of the magnetic field, the shaped magnetic field portion at least partially extending through the workpiece and outwardly beyond a second surface of the workpiece; and



5 a second portion including a magnetic field sensor moveable through at least a portion of the shaped magnetic field portion extending outwardly beyond the second surface, the magnetic field sensor being adapted to sense a characteristic of the shaped magnetic field portion indicative of the desired position for the manufacturing operation.

22. The manufacturing assembly of Claim 21, wherein the manufacturing tool includes a drilling device.

10 23. The manufacturing assembly of Claim 21, wherein the magnet includes an electromagnet.

24. The manufacturing assembly of Claim 21, wherein the at least one field-directing member includes a conically-shaped field-directing portion.

15 25. The manufacturing assembly of Claim 21, wherein the at least one field-directing member includes an axisymmetrically-shaped field-directing portion.

20 26. The manufacturing assembly of Claim 21, wherein the at least one field-directing member includes an outer portion having a first magnetic permeability and an inner portion having a second magnetic permeability.

27. The manufacturing assembly of Claim 21, wherein the shaped magnetic field portion includes an approximately spherical portion.

25 28. The manufacturing assembly of Claim 21, wherein the shaped magnetic field portion includes an approximately axisymmetrical portion.



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29. The manufacturing assembly of Claim 21, further comprising a position control assembly operatively coupled to at least one of the sensing system and the manufacturing tool.

5 30. The manufacturing assembly of Claim 29, wherein the position control assembly is operatively coupled to at least one of the field-directing member and the magnetic field sensor of the sensing system.

10 31. The manufacturing assembly of Claim 29, wherein the position control assembly is operatively coupleable to the workpiece.

32. The manufacturing assembly of Claim 29, wherein the position control assembly includes:

15 a track assembly adapted to be operatively coupleable to the workpiece; and
a carriage assembly operatively coupled to the track assembly and to the respective at least one of the sensing system and the manufacturing tool.

20 33. The manufacturing assembly of Claim 29, wherein the position control assembly further includes a controller operatively coupled to the carriage assembly and adapted to transmit one or more control signals to the carriage assembly to controllably position the carriage assembly with respect to the workpiece.

25 34. The manufacturing assembly of Claim 33, wherein the position control assembly is operatively coupled to at least one of the field-directing member and the magnetic field sensor of the sensing system.

35. A method of performing a manufacturing operation on a workpiece, the method comprising:



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providing a shaped magnetic field portion originating from a first side of the workpiece and extending through the workpiece and outwardly from a second side of the workpiece;

5 traversing a sensor along a first path at least partially through the shaped magnetic field portion extending outwardly from the second side of the workpiece;

sensing a characteristic of the shaped magnetic field portion; and

determining a desired location for performing the manufacturing operation on the workpiece based on the sensed characteristic of the shaped magnetic field portion.

10 36. The method of Claim 35, wherein providing a shaped magnetic field portion includes emanating a plurality of magnetic field lines from a magnet, and shaping at least a portion of the plurality of magnetic field lines using a field-directing member.

15 37. The method of Claim 36, wherein emanating a plurality of magnetic field lines from a magnet includes emanating a plurality of magnetic field lines from an electromagnet.

38. The method of Claim 36, wherein shaping at least a portion of the plurality of magnetic field lines includes shaping at least a portion of the plurality of magnetic field lines using a supplemental field-directing member from the second side of the workpiece.

20 39. The method of Claim 36, wherein shaping at least a portion of the plurality of magnetic field lines includes shaping at least a portion of the plurality of magnetic field lines using a conically-shaped portion of the field-directing member.

25 40. The method of Claim 36, wherein shaping at least a portion of the plurality of magnetic field lines includes shaping at least a portion of the plurality of magnetic field lines using an axisymmetrically-shaped portion of the field-directing member.

30 41. The method of Claim 36, wherein shaping at least a portion of the plurality of magnetic field lines includes shaping at least a portion of the plurality of magnetic field lines



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using an inner portion of the field-directing member having a first magnetic permeability, and an outer portion of the field-directing member having a second magnetic permeability.

42. The method of Claim 35, wherein traversing a sensor along a first path at least 5 partially through the shaped magnetic field portion includes manually traversing the sensor along the first path.

43. The method of Claim 35, wherein traversing a sensor along a first path at least 10 partially through the shaped magnetic field portion includes traversing the sensor along the first path using a position control assembly.

44. The method of Claim 35, wherein traversing a sensor along a first path at least partially through the shaped magnetic field portion includes traversing the sensor along the first path using a position control assembly operatively coupled to the workpiece.

15 45. The method of Claim 35, wherein traversing a sensor along a first path at least partially through the shaped magnetic field portion includes traversing the sensor along the first path at a constant distance from the workpiece.

20 46. The method of Claim 35, wherein traversing a sensor along a first path at least partially through the shaped magnetic field portion includes traversing the sensor through an approximately-spherical portion of the shaped magnetic field portion.

25 47. The method of Claim 35, wherein traversing a sensor along a first path at least partially through the shaped magnetic field portion includes traversing the sensor through an approximately-axisymmetrical portion of the shaped magnetic field portion.

30 48. The method of Claim 35, wherein sensing a characteristic of the shaped magnetic field portion includes, sensing a characteristic simultaneously with traversing the sensor along the first path at least partially through the shaped magnetic field portion.



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49. The method of Claim 35, wherein determining a desired location for performing the manufacturing operation on the workpiece includes determining a center of an approximately spherical portion of the shaped magnetic field.

5 50. The method of Claim 35, wherein determining a desired location for performing the manufacturing operation on the workpiece includes determining a center of an approximately axisymmetrical portion of the shaped magnetic field.

10 51. The method of Claim 35, wherein determining a desired location for performing the manufacturing operation on the workpiece includes determining a location on the second side of the workpiece along a longitudinal axis of the shaped magnetic field.

52. The method of Claim 35, further comprising performing the manufacturing operation at the desired location on the workpiece.

15 53. The method of Claim 35, further comprising performing a drilling operation at the desired location on the workpiece.

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